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(54) Title of Invention: **Coolant Circuit Simulation Method**

(57) **Abstract**

Problem: To make input operations for conducting simulations of coolant circuits as simple as possible.

Means for Resolution: A data file wherein were stored the specifications and characteristic computation formula(s) for a compressor and heat exchanger configuring a coolant circuit was provided, and the following steps were provided, namely a compressor setting step for setting the compressor to be used and the model name thereof, a heat exchanger setting step for setting the model name of the heat exchanger to be connected to said compressor, a connection relationship building step for building a relationship for connecting the set compressor and heat exchanger, a simulation program generation step for generating a simulation program based on the set compressor and heat exchanger model names, and a simulation execution step wherein the generated simulation program performs simulation computations based on the specifications and characteristic computation formula(s) for said compressor and heat exchanger.

[Figure:]

1 Display monitor

User interface

2 Keyboard

Generation

Generation

9 Sub-program file group

Claims

Claim 1 A coolant circuit simulation method comprising a data file wherein are stored the specifications and characteristic computation formula(s) for a compressor and heat exchanger configuring a coolant circuit, having the following steps, namely: (a) a compressor setting step for setting the compressor to be used and the model name thereof, (b) a heat exchanger setting step for setting the model name of the heat exchanger to be connected to said compressor, (c) a connection relationship building step for building a relationship for connecting the set compressor and heat exchanger, (d) a simulation program generation step for generating a simulation program based on the set compressor and heat exchanger model names, and (e) a simulation execution step wherein the generated simulation program performs simulation computations based on the specifications and characteristic computation formula for said compressor and heat exchanger.

Claim 2 The coolant circuit simulation method according to claim 1, [further] having an identical combination detection step for detecting, from among combinations of compressors and heat exchangers, identical combinations thereof, using the connection relationship set in said connection relationship building step, the model name of the compressor set in said compressor setting step, and the model name of the heat exchanger set in said heat exchanger setting step.

Claim 3 The coolant circuit simulation method according to claim 1, wherein said heat exchanger setting step has a model name specification modification step for modifying

the specifications of a model name selected from among registered model names, when no suitable model name has been registered for the set heat exchanger.

Claim 4 The coolant circuit simulation method according to claim 3, [further] having a model name registration step for registering a heat exchanger having specifications as modified in said model name specification modification step, attaching a new model name thereto.

Claim 5 The coolant circuit simulation method according to claim 1, wherein said compressor setting step has a parameter modification step for modifying the parameters of the characteristic computation formula for said compressor.

Claim 6 The coolant circuit simulation method according to claim 5, [further] having a computation formula registration step for registering the computation formula modified in said parameter modification step as a new characteristic computation formula.

Claim 7 The coolant circuit simulation method according to claim 1, wherein said simulation execution step has steps for performing characteristic computations for the compressor and the heat exchanger based on some assumed vaporization temperature and condensation temperature, computing the coolant flow volumes for the compressor and heat exchanger in each coolant circuit, and judging coincidences of those coolant flow volumes.

Claim 8 The coolant circuit simulation method according to claim 1, wherein a plurality of computation formulas is associated with one heat exchanger in the data file in which said characteristic computation formulas are stored, and said model name setting step has a step for selecting a characteristic computation formula for the set heat exchanger.

Detailed Description of the Invention

[0001]

Technical Field of the Invention: The present invention relates to a simulation apparatus for simulating a refrigerator or air conditioner configured by pipeline-connecting a compressor to a heat exchanger such as an evaporator or condenser or the like, and particularly to a method for simulating a refrigerator or air conditioner coolant circuit.

[0002]

Prior Art: Refrigerators and air conditioners and the like have a heat exchanger or the like typified by a compressor, evaporator, or condenser, as a constituent element thereof. These elements are connected in a pipeline system. Accordingly, when designing a refrigerator or air conditioner, simulations are performed, and the performance of that coolant circuit is analyzed. However, in order to study the performance balance between the compressor and the heat exchanger, or the specifications of the heat exchanger, simulations are done repeatedly while changing the conditions time and again. Furthermore, when inputting the specifications of the compressor or heat exchanger in order to execute the simulations, data inputs must be done one at a time. As relating to the pipeline connections, moreover, every time the

configuration of the coolant circuit is modified, a simulation program must be created.

[0003]

Problems Solved by the Invention: Thus, conventionally, in order to perform simulations on a coolant circuit in a refrigerator or air conditioner or the like, a simulation program must be created for that coolant circuit, or an existing program must be modified, and much data such as compressor or heat exchanger specifications, or physical values for the coolant, air, and water or the like, must be input. For that reason, because input misses occur when creating the simulation program or inputting the voluminous data by hand, an enormous amount of time is required before the simulations are completed, and product development time becomes long. These are problems.

[0004] An object of the present invention, which was devised for the purpose of resolving such problems as noted above, is to provide a simulation method wherewith compressor or heat exchanger specification settings can be made with great ease and in a short time, and also wherewith accurate coolant pipeline connection settings can be easily made.

[0005]

Means for Resolving Problems: The coolant circuit simulation method to which the present invention relates comprises a data file wherein are stored specifications and characteristic computation formulas for the compressor and heat exchanger which configure the coolant circuits, and has the following steps, namely (a) a compressor setting step for setting the compressor to be used and the model name thereof, (b) a

heat exchanger setting step for setting the model name of the heat exchanger to be connected to the compressor, (c) a connection relationship building step for building a relationship for connecting the set compressor and heat exchanger, (d) a simulation program generation step for generating a simulation program based on the set compressor and heat exchanger model names, and (e) a simulation execution step wherein the generated simulation program performs simulation computations based on the specifications and characteristic computation formula for the compressor and heat exchanger.

[0006] [The simulation method] also has an identical combination detection step for detecting, from among combinations of compressors and heat exchangers, identical combinations thereof, using the connection relationship set in the connection relationship building step, the model name of the compressor set in the compressor setting step, and the model name of the heat exchanger set in the heat exchanger setting step.

[0007] In addition, the heat exchanger setting step has a model name specification modification step for modifying the specifications of a model name selected from among registered model names, when no suitable model name has been registered for the set heat exchanger.

[0008] [The simulation method] also has a model name registration step for registering a heat exchanger having specifications as modified in the model name specification modification step, attaching a new model name thereto.

[0009] Furthermore, the compressor setting step has a parameter modification step for modifying the parameters of the characteristic computation formula for the compressor.

[0010] [The simulation method] also has a computation formula registration step for registering the computation formula modified in the parameter modification step as a new characteristic computation formula.

[0011] Also, the simulation execution step has steps for performing characteristic computations for the compressor and the heat exchanger based on some assumed vaporization temperature and condensation temperature, computing the coolant flow volumes for the compressor and heat exchanger in each coolant circuit, and judging coincidences of those coolant flow volumes.

[0012] [In the simulation method], moreover, a plurality of computation formulas is associated with one heat exchanger in the data file wherein the characteristic computation formulas are stored, and the model name setting step has a step for selecting a characteristic computation formula for the set heat exchanger.

[0013]

Embodiments of the Invention

Embodiment 1: Figs. 1 to 7 are diagrams representing one embodiment of the coolant circuit simulation method according to the present invention. Fig. 1 is a diagram of the overall configuration of this coolant circuit simulation method. In Fig. 1, item 1 is a

display monitor, such as a CRT or the like, for displaying input screens for entering data in order to perform simulations, or displaying simulation results. Item 2 is an input device such as a keyboard for entering data. Item 3 is a database file wherein is stored specification information for compressors or heat exchangers. Item 4 is a simulation processor for executing simulations. This simulation processor 4 is configured by a preprocessor 5 for converting input data to computational data, a generator 6 for creating simulation programs, a main processor 7 for performing coolant circuit simulations, and a post-processor 8 for graphically displaying simulation results produced by the main processor 7 on the display monitor 1. Item 9 is a program file group wherein are stored computation formulas and data for defining the specifications of the elements which configure the coolant circuit. And item 10 is an output file wherein are stored the detailed results produced by the simulation executed by the main processor 7.

[0014] Fig. 2 is a flowchart indicating the processing routines for the simulation processor 4. Fig. 3 is a flowchart indicating the details of the processing routines for the preprocessor 5 which configures the simulation processor 4. Fig. 4 is an example wherein pipeline connection data produced during the processing of the preprocessor 5 are displayed in an array. Fig. 5 is a diagram representing a computation method for coolant circuits not belonging to the same coolant circuit. Fig. 6 is a diagram representing a computation method for coolant circuits belonging to the same coolant circuit. And Fig. 7 is a flowchart indicating processing routines for performing a coolant circuit simulation based on a coolant circuit set by execution of the preprocessor 5.

[0015] The operations of this embodiment 1 are now described with reference to the drawings. The overall operations are first described with reference to Fig. 2. In step S201, the preprocessor 5, in accordance with data input from the keyboard 2 by an operator (a person performing a simulation), such as the compressor and heat exchanger connection relationship and the model names and the like of the compressor and the heat exchanger (the connection relationship setting step and model name setting step), selects necessary sub-programs from the sub-program group 9 (part of the data file), and generates a generator for linking those (part of the simulation program generation step). The generated generator 6 is run in step S202, and the main processor 7, that is, the simulation program, is generated (part of the simulation program generation step). In step S203, the generated main processor 7 reads in specification data relating to the configuring elements (compressor, evaporator, condenser) from the database file 3 (part of the data file), performs simulation computations, and stores the simulation results in the output file 10 (simulation execution step). The simulation results are graphically displayed on the display monitor 1 by the post-processor 8 in step S204.

[0016] Next, the details of the processing routine of the preprocessor 5 in step S201 are described with reference to Fig. 3. Fig. 3 indicates in detail the pipeline setting input processing and the processing routines executed by the preprocessor 5 in step S201. First, in step S301, the operator is instructed on a screen on the display monitor 1 to set the coolant pipeline connections. In step S302, the operator designates the compressor in the circuit to be set, using the keyboard 2, while observing the screen on

the display monitor 1 (compressor setting step). The preprocessor 5 judges whether or not there is a heat exchanger such as an evaporator or condenser for connection to the compressor designated by the operator in step S303 [*sic: original ambiguity retained*].

(1) When heat exchangers to be connected exist

In this case, in step 304, an evaporator for connection to the designated compressor is designated (part of the heat exchanger setting step). Next, in step S305, a decision is made as to whether or not any evaporators to be connected, besides the evaporator designated in step S304, also exist; when such do exist, the number of evaporators is counted in step S306, another evaporator is designated in step S304 again, and the processing from step S304 to step S306 is repeated until all of the evaporators to be connected are designated. For cases also where condensers exist which are to be connected to the compressor, the processing from step S307 (part of the heat exchanger setting step) to step S309 is repeated by the same procedure as in the case of evaporators.

(2) When no heat exchangers to be connected exist

When it has been judged in step S303 that no heat exchangers to be connected to the compressor exist, the processing is advanced to step S310, and a decision is made as to whether or not another condenser has been designated in step S302. When such has been designated, step S302 is again returned to, and the processing from step S303 to step S310 is repeated. In step S310, when no other condenser has been designated, step S311 is advanced to.

[0017] Thus, when combinations with heat exchangers have been determined for all of the designated compressors, in step S311, combinations with designated heat exchangers for each compressor are compared, and, if the combinations are the identical, step S312 is advanced to and those condensers are judged to belong to the same circuit. When the combinations differ, step S313 is advanced to, and processing which deems [that] to be another circuit is performed.

[0018] Fig. 4 is one example wherein pipeline connection data created in step S311 (connection relationship creation step) diagrammed in Fig. 3 are displayed in an array. Column 41 represents the compressor number, and, in this example, ten compressors can be set. Row 42, meanwhile, represents evaporators and condensers. In this example, ten evaporators can be set, from row numbers 1 to 10, and ten condensers can be set, from row numbers 11 to 20. In the array in the example diagrammed in Fig. 4, it is shown that, by inputting 1s to elements, the evaporator of row number 1 and the condenser of row number 11 are connected to the compressor of column number 1, the evaporator of row number 2 and the condenser of row number 12 are connected to the compressor of column number 3, and the evaporator of row number 1 and the condenser of row number 11 are connected to the compressor of column number 5. By representing the pipeline connection data in this manner, if the difference between row vectors which are not [in] a zero array are found, and a judgment is made as to whether or not [such] will become zero, combinations of heat exchangers connected to condensers can easily be compared.

[0019] In Fig. 5 is diagrammed a computation method for coolant circuits which do not belong to the same coolant circuit. In this example, the difference between the 1st row vector and the 3rd row vector in Fig. 4 is found, and, from the fact that that does not become zero, it is learned that the coolant circuits represented by these two vectors belong to different circuits.

[0020] In Fig. 6, a computation method for coolant circuits belonging to the same coolant circuit is diagrammed. From the fact that the difference between the 1st row vector and the 5th row vector in Fig. 4 becomes zero, it is learned that the coolant circuits represented by these two vectors belong to the same circuit, and that the 1st evaporator and the 11th condenser are connected to two compressors, namely the 1st and the 5th.

[0021] Next, the processing executed by the main processor 7 in step S203 is described with reference to the flow chart in Fig. 7. Fig. 7 diagrams computational routines for performing coolant circuit simulations executed by the main processor 7, based on the coolant circuits set in the processing of the preprocessor 5. First, in step S701, the operator, using the keyboard 2, allots (an) evaporator(s) and (a) condenser(s) to each coolant circuit. In the main processor 7, characteristic computations for the condensers are performed based on the evaporation temperature and condensation temperature set by the operator in step S702, and the coolant flow volumes are found. Next, in step S703, characteristic computations for the evaporators are performed and the coolant flow volumes are found. Then, in step S704, characteristic computations for the condensers are performed and the coolant flow volumes are found. Then, in step 705,

the coolant flow volumes found from the characteristic computations for the compressors, evaporators, and condensers are totaled for the compressor group, evaporator group, and condenser group belonging to the same coolant circuit. Last of all, in step S706, the compressor group coolant flow volumes, evaporator group coolant flow volumes, and condenser group coolant flow volumes found in step S705 are compared for each coolant circuit, and, if they all agree, the simulation is complete. If the coolant flow volumes differ, step S707 is advanced to, and the operator is prompted to again assume and set evaporation temperatures and condensation temperatures for each circuit. After that, from the keyboard 2, the operator redoes the characteristic computations from step S702, using the reset evaporation and condensation temperatures.

[0022] In embodiment 1 described above, moreover, the database file 3 and sub-program file group 9 are configured in separate file units, but there is no absolute requirement that they be separate file units, and they may be configured in the same file unit.

[0023] Thus, as based on this embodiment 1, the coolant pipeline settings can be built with a minimum of inputs, wherefore creating a model of a coolant circuit having a plurality of compressors and heat exchangers in parallel can be done in a short time.

[0024] Embodiment 2: Figs. 8, 9, and 10 are diagrams for describing in detail the method, in the coolant circuit simulation method according to the present invention, for setting the compressor specifications. Fig. 8 is a diagram depicting an example of an

input screen for entering compressor specifications. Fig. 9 is a diagram depicting one example of an input screen for setting the specifications by entering the model name for the compressor designated from the input screen depicted in Fig. 8. And Fig. 10 depicts one example of an input screen for setting the data necessary for the characteristic computations for another compressor having the performance curve for the compressor set using the input screen diagrammed in Fig. 9. With this embodiment 2, a description is given for a method of setting compressor specifications data in a single batch using the model name.

[0025] The processing in this embodiment 2 is now described, making reference to the drawings. In Fig. 8, item 81 is a screen area displaying the content of the input screen currently being worked in, while 82 is a screen area wherein such things as the coolant circuit diagram and a list or the like of the elements such as compressors or heat exchangers configuring the coolant circuit currently being set are graphically processed and displayed. Item 83 is a screen area for entering data, that is, the number of the coolant circuit built; in this example, 1 (COMPO1) is entered. Item 84 is a screen area for displaying items for selection in the input content entered in the input screen area. Item 85 is a screen area wherein the input screen switching method is displayed. Here, the compressor for which one wishes to set compressor specifications based on the coolant circuit diagram displayed in the screen area 82 is designated.

[0026] Next, the model name is set, using the input screen depicted in Fig. 9, for the compressor for which the specifications shown in Fig. 8 are to be set. In Fig. 9, item 91 is a screen area wherein is displayed a list of the model names of the compressors

registered as a database in the database file 3. Item 92 is a screen area for selecting and entering the number of the model name desired from the compressor model name list displayed in the screen area 91; in this example, 18 will be entered, the compressor of model name MR-6SS-60 will be selected, and data for the computation formula for computing the performance curve of the compressor of model name MR-6SS-60 will be set in a single batch.

[0027] Next, the data required for doing the characteristic computations for the compressor set by model name using the input screen depicted in Fig. 9 are set using the input screen depicted in Fig. 10. Fig. 10 depicts one example of an input screen for setting the data required for computing the performance curve for the compressor set by model name using the input screen in Fig. 9 together with other characteristics of the compressor. The characteristic computation formula and compressor type are set according to Fig. 9, and the frequency and effective electrical input coefficient are input from this screen. In the compressor characteristic computation, moreover, when one wishes to take into consideration the pressure loss between the pipelines on the intake and discharge sides of the compressor, entries are made for the items from pressure loss consideration on (parameter modification step). This computation formula with modified parameters can be registered as a new characteristic computation formula (computation formula registration step), and employed in the processing from then on. Thus, the computational data required for compressor characteristic computation can be set with a minimum of inputs, and input errors held down to a minimum.

[0028] According to this embodiment 2, as described in the foregoing, all of the compressor specifications required for a characteristic computation can be set merely by entering the model name. Also, because partial modifications may be made, as necessary, data entry labor can be reduced, and input errors held down to a minimum. It is also possible to modify a portion of the specifications and register [the result] under a new model name.

[0029] Embodiment 3: Figs. 11 and 12 are figures for describing the details of a method for setting the heat exchanger specifications in the coolant circuit simulation method according to the present invention. Fig. 11 depicts an example of a screen for setting the specifications of the heat exchanger to be used by the model name, while Fig. 12 depicts an example of a screen for displaying the specifications set according to Fig. 11 and also for modifying some of those specifications. This embodiment 3 is one wherein the specifications of the heat exchanger to be used are set in a single batch by entering the model name.

[0030] The operations in this embodiment 3 are now described while referring to the drawings. After selecting the heat exchanger which one wishes to set, based on the coolant circuit diagram, the number of the model name which one wishes to set is entered from the list of registered heat exchanger model names displayed on the screen depicted in Fig. 11. In the example given on this screen, number 21 is entered to select the heat exchanger having the model number MSZ2801. If there is no suitable model number in the list of registered heat exchanger model names, a model name having

similar specifications is selected, and those specifications are modified accordingly.

[0031] The list of specifications for the heat exchanger set by entering the model name on the screen depicted in Fig. 11 is displayed on a screen such as that depicted in Fig. 12. On this screen, when specifications set in a single batch by model name are to be modified, [such] modifications can be made by the input screen common input method of entering post-modification values, after making a selection by entering the number of the item one wishes to modify (model name specification modification step). In this example, number 24 is entered, and the pitch is modified. It is also possible to give a heat exchanger for which the specifications have been modified a new model name and registering it (model name registration step), and to employ [that heat exchanger] in subsequent simulation using the newly registered model name.

[0032] Thus, based on this embodiment 3, all of the heat exchanger specifications required for characteristic computation can be set merely by entering the model name. Also, because partial modifications may be made, as necessary, data entry labor can be reduced, and input errors held down to a minimum. It is also possible to modify a portion of the specifications and register [the heat exchanger] under a new model name.

[0033] Embodiment 4: Fig. 13 is a diagram for describing another embodiment of the coolant circuit simulation method according to the present invention. Fig. 13 depicts one example of the configuration of a plurality of computation formulas contained in one file in the sub-program group 9. In the example depicted in Fig. 13, computation

formulas for finding the overall heat transfer coefficient of three heat exchangers of different shape are comprehended in three files, and a plurality of computation formulas is stored in the individual files. That is, in the files 'KFIN,' 'KTUBU,' and 'KSHEL,' indicated at 131, overall heat transfer coefficients for each of the heat exchangers, that is, for a plate-fin-tube, a tube-in-tube, and a shell-tube heat exchanger, are comprehensively stored. In determining which computation formula to select, the type of heat exchanger, that is, the file, is selected on an input screen that is not depicted in the drawings, and the computation formula to be used is then selected. With the computation formula selected from the input screen, by passing the indexes held by the individual computation formulas, as indicated at 132, between programs, computational processing can be performed using the selected computation formula. By adding such indexes, moreover, it is also possible to easily add computation formulas.

[0034] Thus, based on this embodiment 4, provision is made so that the computation formula used in the characteristic computation can be selected, wherefore simulations closer to the actual design can be performed.

[0035]

Advantages of the Invention: Thus, based on the present invention, provision is made so that data required for characteristic computations can be input in a single batch merely by entering the model name, wherefore coolant pipeline settings can be built with a minimum of inputs, and the modeling of coolant circuits having pluralities of compressors and heat exchangers in parallel can be done in a short time. Input misses can also be reduced. The present invention also is advantageous in that the process

time for passing data input by model name in single batches back and forth between computational processors can be shortened, and compressor and heat exchanger specification data can be accumulated.

[0036] In addition, provision is made for detecting identical coolant circuits from among a plurality of coolant circuits, and provision is made so that simulations for identical coolant circuits are displayed with one coolant circuit, wherefore there is no longer any need to perform superfluous simulations, and processing efficiency is enhanced.

[0037] Furthermore,, when a heat exchanger to be used in a coolant circuit has not been registered, provision is made so that the specifications of a registered heat exchanger having similar specifications can be modified and [that heat exchanger] used, so the input operation is simplified.

[0038] Additionally, provision is made so that a heat exchanger the specifications whereof have been modified can be registered as a new heat exchanger, wherefore the processing efficiency of the next and following simulations is enhanced.

[0039] Also, provision is made so that parameters can be modified when conducting characteristic computations for compressors, wherefore there is no need to create new computation formulas, and simulations can be performed with simple operations.

[0040] Furthermore, provision is made so that characteristic computation formulas the parameters whereof have been modified can be newly registered, wherefore the processing efficiency of the next and following simulations is enhanced.

[0041] Also, provision is made so that simulations are performed such that the coolant flow volumes of the compressors and heat exchangers coincide in each coolant circuit, resulting in simulations of good precision.

[0042] Also, provision is made so that files are configured with a plurality of characteristic computation formulas associated with one heat exchanger, and so that suitable characteristic computation formulas can be selected, wherefore operation is simplified, and the execution efficiency of simulations closer to the actual design improves.

Brief Description of the Drawings

Fig. 1 is a diagram representing one embodiment of a coolant circuit simulation apparatus according to the present invention.

Fig. 2 is a flowchart indicating simulation processor processing routines.

Fig. 3 is a flowchart indicating preprocessor processing routines.

Fig. 4 is a diagram wherein pipeline connection data created in preprocessor processing are represented by an array.

Fig. 5 is a diagram of a computation method for coolant circuits not belonging to the same coolant circuit.

Fig. 6 is a diagram of a computation method for coolant circuits belonging to the same coolant circuit.

Fig. 7 is a flowchart indicating routines for executing a coolant circuit simulation.

Fig. 8 is a diagram depicting an example of a display on an input screen for selecting compressors in embodiment 2.

Fig. 9 is a diagram depicting an example of a display on an input screen for determining the specifications of a selected compressor by inputting the model name.

Fig. 10 is a diagram depicting an example of a display on an input screen for entering data for performing characteristic computations for a selected compressor.

Fig. 11 is a diagram depicting an example of a display on an input screen for selecting a heat exchanger by inputting the model name in embodiment 3.

Fig. 12 is a diagram depicting an example of a display on an input screen for listing specification data for a selected heat exchanger and entering data for modifying specifications.

Fig. 13 is a diagram representing one example of the configuration of a file for computation formulas for performing characteristic computations in embodiment 4.

Explanation of Symbols

1 display monitor, 2 keyboard, 3 database file, 4 simulation processor, 5 preprocessor, 6 generator, 7 main processor, 8 post-processor, 10 output file, 41 compressor number, 42 evaporator and condenser number, 131 file name.

[Keys to text in drawings]

Fig. 1

1 Display monitor

User interface

2 Keyboard

Generation

Generation

9 Sub-program file group

Fig. 2

S201 PreProcessor Execution

Select sub-program to be used

Create Generator

S202 Generator Execution

Create Main Processor

(Include & Link)

S203 Main Processor Execution

Read in data base

Compute coolant circuit

Output detailed data

S204 Post Processor Execution

Designate graph type

Output graph

Fig. 3

S301 Set coolant circuit connections

S302 Designate compressor

S303 Is there an evaporator or condenser to be connected?

S304 Set evaporator No.

S305 Will another evaporator be connected?

S306 Count number of evaporators

S307 Designate condenser No.

S308 Will another condenser be connected?

S309 Count number of condensers

S310 Will another compressor be designated?

S311 Compare combinations of evaporators and/or condensers connected to each compressor designated

When they are the same

S312 Consider to be the same circuit

When they differ

S313 Consider to be different circuits

Fig. 7

S701 Postulate evaporation temperature, condensation temperature

S702 Compute compressor characteristics

S703 Compute evaporator characteristics

S704 Compute condenser characteristics

S705 Compute coolant flow volumes of the elements in each circuit

S706 Do the coolant flow volumes of the elements in each circuit coincide?

S707 Repostulate evaporation temperature and condenser temperature for each circuit

YES

End

Fig. 8

/ 81 / 82 / 84

Compressor setting mode

Evaporator Compressor Condenser

[see diagram in original]

Current setting values		
Compressor No.	Computation formula	Model name
1	Performance formula	KHV127
2		
3		
4		
5		
6		
7		
8		
9		
10		

Number of compressor to be designated or modified

1 COMPO1
2
3
4
5
6
7
8
9
10

Please enter the appropriate compressor No. 1

Compressor #4

99 To compressor setting screen

-9 Return to previous screen

83 / \ 85

Fig. 13

/ 131 / 132

File name	Type	Overall heat transfer coefficient INDEX	Overall heat transfer symbol
KFIN		INDEX(1) = 1	KT (generalized formula 1)
		= 2	KT (generalized formula 2)
		= 3	KI (generalized formula 1)
		= 4	KI (generalized formula 2)
		= 5	KT (experimental formula)
		= 6	KI (experimental formula)
KTUBE	Wet	INDEX(6) = 1	KT (generalized formula)
	Dry	= 2	KT (generalized formula)
	Dry	= 3	KT (generalized formula)
	Dry	= 4	KT (= KT)
	Wet	= 5	KT (= KT)
KSHELL	Wet	INDEX(6) = 1	KT (generalized formula)
	Wet	= 2	KT (= KT)

Fig. 9

/ 91

Compressor setting mode Evaporator Compressor Condenser [see diagram in original]	Registered compressor model name list 1 2 3 4 5 6 7 8 9 10 11 MR-4SS-50 12 MR-4SS-60 13 MR-4MS-50 14 MR-4MS-60 15 MR-4LS-50 16 MR-4LS-60 17 MR-6SS-50 18 MR-6SS-60 19 MR-6MS-50 20 MR-6MS-60
	Heat exchanger #7
Please enter the number of the compressor model name. 18 (1 - 10 are user-registered compressors.)	999 Next page -9 Return to previous screen

92/

Fig. 10

Compressor setting mode		
Evaporator Compressor Condenser [see diagram in original] Characteristic computation formula → [Performance formula] Compressor → [RHV154] [Electrostatic air conditioner scheme] Frequency → [60.0 (Hz)] Effective electrical [illegible] input coefficient → [0.75] Pressure loss consideration → [Consider] Intake line inner diameter → [10.30 (mm)] Intake line length → [7.0 (M)] Discharge line inner diameter → [7.0 (mm)] Discharge line length → [1.20 (M)]		
Do you wish to modify the specifications of another compressor? (Y/N) N		Compressor #13 -9 Return to previous screen

Fig. 11

Heat exchanger physical shape input mode

Evaporator Compressor Condenser

[see diagram in original]

Setting List			
		Model name	Type
1	HE01	MSZ2801	Fin & tube
2	HE02		Fin & tube
3	HE03		Fin & tube
4	HE04		Fin & tube
5	HE05		Fin & tube
6	HE06		Fin & tube
7	HE07		Fin & tube
8	HE08		Fin & tube
9			
10			
11	HC01	MUZ2801	Fin & tube
12			
13			
14			
15			
16			
17			
18			
19			
20			

Registered heat exchanger model name list

21 MSZ2801
22 MTZ2810
23 MTZ4010
24 MTZ2211
25 MLZ2810
26 MLZ4010
27 MBZ2810
28 MBZ4010
29 MEH2820
30 MEH4020
31 MEZ6311
32 MUZ2801
33 MUH2831
34 MXZ6710
35 MXZ5010
36 PLH71FKD
37 PCH71EKD
38 PKH71EKD
39 PLH125FKD
40 PCH125EKD

For new [cases], please select similar item and register model name after modifying.
Please enter the heat exchanger No. 21
(1 - 20 are user-registered heat exchangers.)

Heat exchanger #3

999 Next page

-9 Return to previous screen

Fig. 12

Heat exchanger physical shape input mode

Evaporator Compressor Condenser

[see diagram in original]

Setting List			
		Model name	Type
1	HE01	MSZ2801	Fin & tube
2	HE02		Fin & tube
3	HE03		Fin & tube
4	HE04		Fin & tube
5	HE05		Fin & tube
6	HE06		Fin & tube
7	HE07		Fin & tube
8	HE08		Fin & tube
9			
10			
11	HC01	MUZ2801	Fin & tube
12			
13			
14			
15			
16			
17			
18			
19			
20			

Heat exchanger shape

1) PIPE side

1 Type = channeled
2 Outer diameter (wide pipe) = 7.0 mm
3 Skin thickness (wide pipe) = 0.26 mm
4 Wide pipe ratio = 105.0%
5 Cutouts = 0
6 Number of passes = 2
7 Number of ranks = 3
8 Number of files = 2
9 Rank pitch = 20.4 mm
10 File pitch = 12.7 mm

11) Fin side

21 Type = Microslit
22 Thickness = 0.110 mm
23 Width PIPE = 12.7 mm
24 Pitch = 1.30 mm
25 Stack length = 665.0 mm

Where are the points of modification in the shape of the heat exchanger? 24

Heat exchanger #4

99 Finished

-9 Return to previous screen

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// G06F　17/00			G06F	15/20	D

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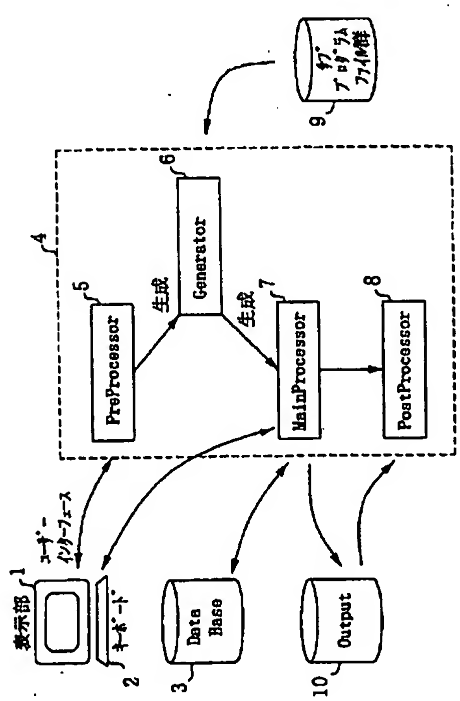
(54)【発明の名称】　冷媒回路のシミュレーション方法

(57)【要約】
【課題】　冷媒回路のシミュレーションを行なうのに、入力操作を極力簡単にする。
【解決手段】　冷媒回路を構成する、圧縮機と熱交換器の仕様および特性計算式を格納したデータファイルを備え、使用する圧縮機とその形名を設定する圧縮機設定工程、前記圧縮機に接続する熱交換器の形名を設定する熱交換器設定工程、設定された圧縮機と熱交換器との接続関係を構築する接続関係構築工程、設定された圧縮機および熱交換器の形名を基にシミュレーションプログラムを生成するシミュレーションプログラム生成工程および生成されたシミュレーションプログラムが前記圧縮機および熱交換器の仕様と特性計算式とを基に、シミュレーション計算を行なうシミュレーション実行工程を設けた。



計算式とを基に、シミュレーション計算を行なうシミュレーション実行工程。

【０００６】また、前記接続関係構築工程で設定された接続関係と、前記圧縮機設定工程で設定された圧縮機の形名と前記熱交換器設定工程で設定された熱交換器の形名と、を用いて圧縮機と熱交換器との組み合わせの中の同一の組み合わせを検出する同一組み合わせ検出工程を有するものである。

【０００７】また、前記熱交換器設定工程は、設定する熱交換器に適切な形名が登録されていない場合には、登録済みの形名の中から選択した形名の仕様を変更する形名仕様変更工程を有するものである。

【０００８】また、前記形名仕様変更工程で変更した仕様の熱交換器を新たな形名を付して登録する形名登録工程を有するものである。

【０００９】また、前記圧縮器設定工程は、前記圧縮器の特性計算式のパラメータを変更するパラメータ変更工程を有するものである。

【００１０】また、前記パラメータ変更工程で変更した計算式を新たな特性計算式として登録する計算式登録工程を有するものである。

【００１１】また、前記シミュレーション実行工程は、ある仮定した蒸発温度と凝縮温度を基に圧縮機および熱交換器の特性計算を行ない、各冷媒回路毎に圧縮機と熱交換器の冷媒流量を計算してその冷媒流量の一致を判断する工程を有するものである。

【００１２】また、前記特性計算式を格納したデータファイルには、１つの熱交換器に複数の計算式が対応付けられていて、前記形名設定工程は、設定する熱交換器に対する特性計算式を選択する工程を有するようにしたものである。

【００１３】

【発明の実施の形態】

実施の形態１．図１乃至図７は、本発明による冷媒回路のシミュレーション方法の一実施の形態を示す図である。図１は、この冷媒回路のシミュレーション方法の全体構成を示す図で、図において、１はシミュレーションを行なうためのデータを入力する入力画面やシミュレーションの結果を表示するＣＲＴ等の表示装置、２はデータを入力するキーボード等の入力装置、３は圧縮機や熱交換器の仕様情報が格納されているデータベースファイルである。４はシミュレーションを実行するシミュレーションプロセッサであり、このシミュレーションプロセッサ４は入力データを演算データに変換するためのプリプロセッサ５、シミュレーションプログラムを作成するためのジェネレータ６、冷媒回路のシミュレーションを行うメインプロセッサ７およびメインプロセッサ７で実行したシミュレーション結果を表示装置１にグラフィック表示するポストプロセッサ８により構成されている。また、９は冷媒回路を構成する各要素の仕様を規定するデータや計算式を格納しているプログラムファイル群、１０はメインプロセッサ７で実行したシミュレーションより求まった詳細結果が格納されるアウトプットファイルである。

【００１４】図2は、シミュレーションプロセッサ４の処理手順を示すフローチャート図、図3はシミュレーションプロセッサ４を構成するプリプロセッサ５の処理手順の詳細を示すフローチャート図、図4はプリプロセッサ5の処理において作成される配管接続のデータを行列で表記した例、図５は同一の冷媒回路に属さない冷媒回路の計算方法を示す図、図６は同一の冷媒回路に属す冷媒回路の計算方法を示す図、図7はプリプロセッサ5の実行により設定された冷媒回路に基づいて冷媒回路のシミュレーションを実行する処理手順を示すフローチャート図である。

【００１５】以下、図を参照しながら、この実施の形態１における動作について説明する。最初に、全体的な動作を図2により説明する。操作者（シミュレーションを実行する人）が、キーボード２から入力した圧縮機と熱交換器との接続関係並びに圧縮機や熱交換器の形名等のデータ（接続関係設定工程および形名設定工程）に従って、プリプロセッサ5がステップＳ２０１においてサブプログラム群９（データファイルの一部）から必要なサブプログラムを選択して、それらをリンクするジェネレータを生成する（シミュレーションプログラム生成工程の一部）。生成されたジェネレータ６をステップＳ２０２で実行して、メインプロセッサ７、即ちシミュレーションプログラムを生成する（シミュレーションプログラム生成工程の一部）。ステップＳ２０３では、生成されたメインプロセッサ7が、データベースファイル３（データファイルの一部）から各構成要素（圧縮機、蒸発器、凝縮器）に関する仕様データを読み込んでシミュレーション計算を行なって、シミュレーション結果をアウトプットファイル１０に格納する（シミュレーション実行工程）。また、シミュレーション結果はポストプロセッサ8によりステップＳ２０４において、表示装置1にグラフィック表示される。

【００１６】次に、ステップＳ２０１におけるプリプロセッサ5の処理手順の詳細を図3により説明する。図3はステップＳ２０１におけるプリプロセッサ5が実行する配管設定入力の処理と処理手順を詳細に示したものである。先ず、ステップＳ３０１において、操作者に対して冷媒配管の接続の設定を行うことを表示装置１の画面上に指定する。ステップＳ３０２において、操作者は、表示装置１の画面を見ながらキーボード２を用いて、設定する回路の圧縮機を指定（圧縮機設定工程）する。プリプロセッサ5は、ステップＳ３０３において操作者から指定された圧縮機に接続される蒸発器または凝縮器等の熱交換器の有無を判定する。

（１）接続する熱交換器が存在する場合

パフォーマンスカーブの他に圧縮機の特性計算に必要なデータを設定する入力画面の一例を示している。この実施の形態２では、形名を用いて圧縮機の仕様データを一括して設定する方法を説明する。

【００２５】以下、図を参照しながら、この実施の形態２における処理について説明する。図８において、８１は現在作業している入力画面の内容を示す画面領域であり、８２は冷媒回路図や現在設定されている冷媒回路を構成する圧縮機や熱交換器等の要素の一覧表等がグラフィック処理されて表示される画面領域である。８３はデータ、即ち構築した冷媒回路の番号を入力する画面領域であり、この例では１（ＣＯＭＰＯ１）が入力されている。８４は、入力画面領域で入力する入力内容の選択項目を示す画面領域である。また、８５は、入力画面の切り替え方法が示されている画面領域である。ここでは画面領域８２に示された冷媒回路図に基づいて圧縮機の仕様を設定したい圧縮機を指定する。

【００２６】次に、図８に示した仕様を設定する圧縮機について、その形名を図９に示す入力画面を用いて設定する。図９において、９１はデータベースファイル３にデータベースとして登録されている圧縮機の形名の一覧が表示される画面領域である。９２は画面領域９１に表示されている圧縮機の形名の一覧の中から希望する形名の番号を選択して入力する画面領域であり、この例では１８が入力され、形名ＭＲ－６ＳＳ－６０の圧縮機が選択されていて、この形名ＭＲ－６ＳＳ－６０の圧縮機のパフォーマンスカーブを計算する計算式のデータを一括して設定していることになる。

【００２７】次に、図９に示した入力画面を用いて形名で設定した圧縮機の特性計算をするために必要なデータを図１０に示す入力画面を用いて設定する。図１０は、図９の入力画面を用いて形名で設定された圧縮機のパフォーマンスカーブと共に圧縮機の他の特性を計算するのに必要なデータを設定する入力画面の一例を示している。特性計算式と圧縮機の種類は図９により設定され、周波数と有効電気入力係数をこの画面で入力する。また、圧縮機の特性計算において、圧縮機の吸入側と吐出側の配管の圧力損失を考慮したい場合には圧損の考慮以降の項目について入力する（パラメータ変更工程）。このパラメータを変更した計算式を新たな特性計算式として登録（計算式登録工程）しておいて、以降の処理で使用することもできる。このように、最小の入力で圧縮機の特性計算に必要な計算データを設定することができ、入力ミスも最小限に押えられる。

【００２８】以上のように、この実施の形態２によれば、形名を入力するだけで特性計算に必要な圧縮機の仕様を全て設定することができる。また、必要に応じて一部を変更するだけで良いのでデータの入力の手間が省け、入力ミスも最小限に押えることができる。さらに、一部の仕様を変更したものを新たな形名を付して登録しておくことができる。

【００２９】実施の形態３．図１１および図１２は、この発明による冷媒回路のシミュレーション方法における熱交換器の仕様を設定する方法の詳細を説明する図である。図１１は使用する熱交換機の仕様を形名により設定する画面の例を示すであり、図１２は図１１で設定した仕様と表示すると共にその仕様の一部を変更するための画面の例を示す図である。この実施の形態３は使用する熱交換機の仕様を形名入力により一括して設定するものである。

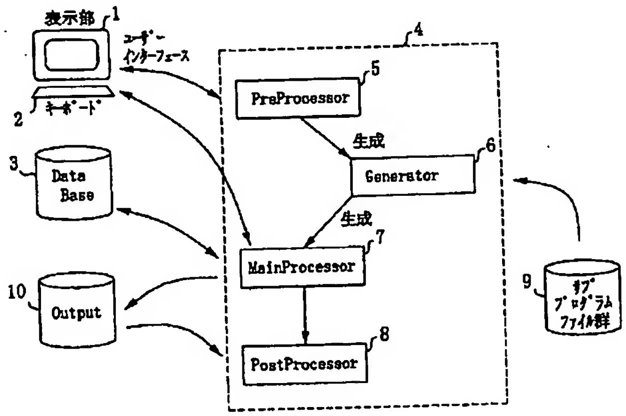
【００３０】以下、図を参照しながら、この実施の形態３における動作について説明する。冷媒回路図に基づいて、設定したい熱交換器を選定した後、図１１に示す画面上に表示されている登録済み熱交換器形名一覧の中から設定したい形名の番号を入力する。この画面の例では、番号２１を入力して、ＭＳＺ２８０１の形名を有する熱交換器を選択している。もし、登録されている熱交換器形名一覧の中に適切なものがない場合には、類似した仕様を有する形名のものを選択して、その仕様を変更することにより対処する。

【００３１】図１１に示した画面で形名入力によって設定された熱交換器の仕様の一覧は、図１２に示すような画面として表示される。この画面においては、形名により一括設定された仕様を変更する場合は、変更したい項目の番号を入力して選択した後、変更後の値を入力するという入力画面共通の入力方法で変更を行うことができる（形名仕様変更工程）。この例では、番号２４が入力され、ピッチの変更を行っている。また、仕様の変更を行なった熱交換機に対して新たな形名を付して登録（形名登録工程）しておいて、以後のシミュレーションにおいては、新たに登録した形名を用いて使用することができる。

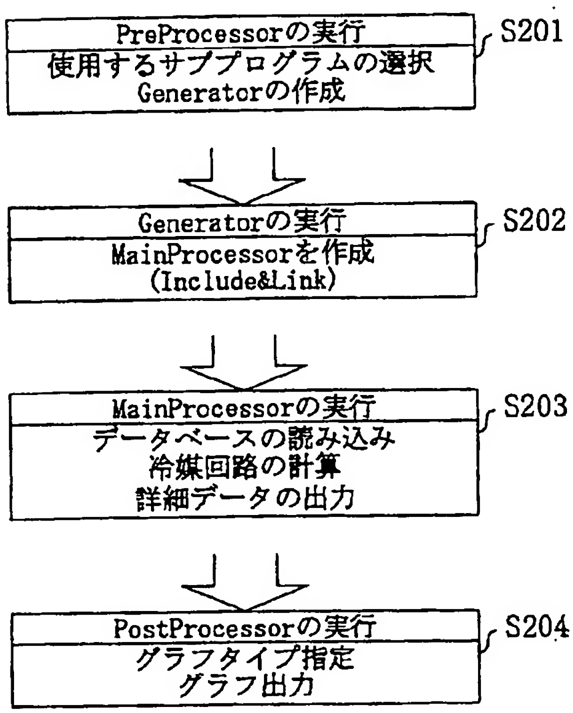
【００３２】以上のように、この実施の形態３によれば、形名を入力するだけで特性計算に必要な熱交換器の仕様を全て設定することができる。また、必要に応じて一部を変更するだけで良いのでデータの入力の手間が省け、入力ミスも最小限に押えることができる。さらに、一部の仕様を変更したものを新たな形名を付して登録しておくことができる。

【００３３】実施の形態４．図１３は、この発明のよる冷媒回路のシミュレーション方法の他の実施の形態を説明する図である。図１３は、サブプログラム群９の中の一つのファイルに含まれる複数の計算式の構成の一例を表している。図１３に示した例では、３つの形状の異なる熱交換器の熱通過率を求める計算式を３つのファイルにまとめて、各々のファイルの中に複数の計算式を格納している。即ち、１３１に示されるファイル’ＫＦＩＮ’、’ＫＴＵＢＵ’および’ＫＳＨＥＬ’には、各々プレートフィンチューブ、チューブインチューブ、シェルチューブの熱交換器の熱通過率計算式がまとめて格納

【図1】



【図2】



【図4】

41

$$42\ \left(\begin{array}{ccccccccccc}
1&0&0&0&1&0&0&0&0&0&0\\
0&0&1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
1&0&0&0&1&0&0&0&0&0&0\\
0&0&1&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0
\end{array}\right)$$

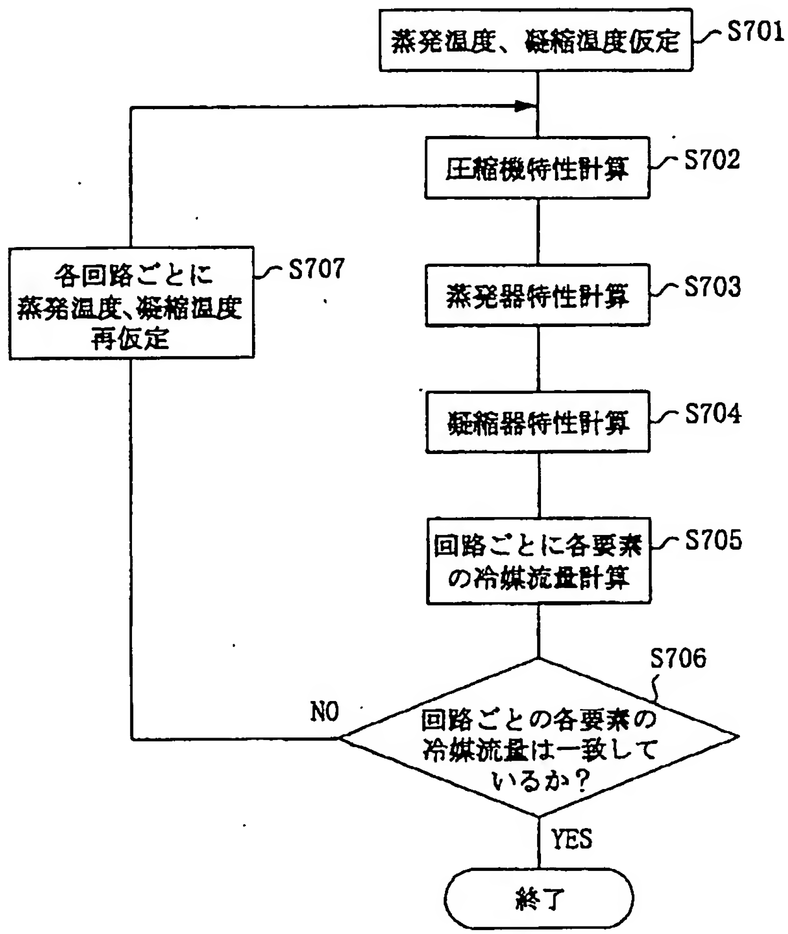
【図5】

$$\begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\\0\\0\\1\\0\\0\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} - \begin{pmatrix}0\\1\\0\\0\\0\\0\\0\\0\\0\\0\\0\\1\\0\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\-1\\0\\0\\0\\0\\0\\0\\0\\0\\1\\-1\\0\\0\\0\\0\\0\\0\\0\\0\end{pmatrix}$$

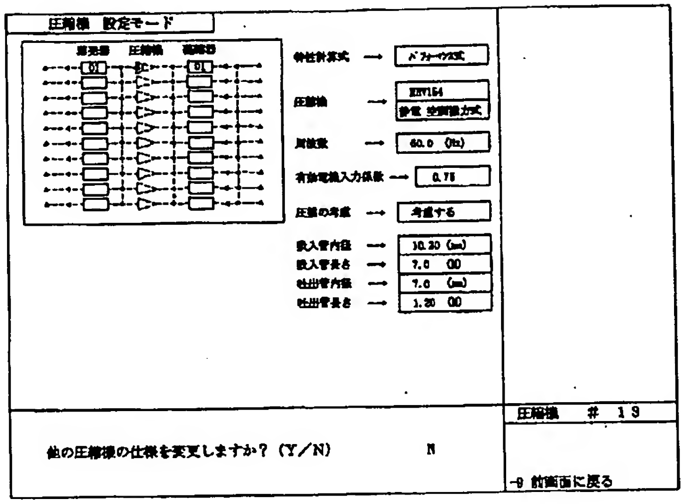
【図6】

$$\begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\\0\\0\\1\\0\\0\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} - \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\\0\\0\\1\\0\\0\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = 0$$

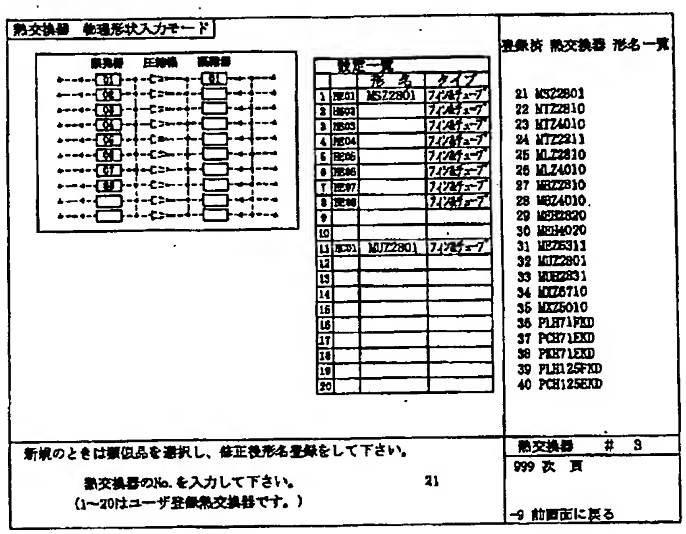
【図7】


蒸発温度、凝縮温度仮定
S701
圧縮機特性計算
S702
蒸発器特性計算
S703
凝縮器特性計算
S704
回路ごとに各要素の冷媒流量計算
S705
S706
回路ごとの各要素の冷媒流量は一致しているか？
NO
YES
終了
各回路ごとに蒸発温度、凝縮温度再仮定
S707

【図10】


圧縮機 設定モード
他の圧縮機の仕様を変更しますか？（Y/N）
N
圧縮機 ＃ 19
-9 前画面に戻る

【図11】


登録済 熱交換器 形名一覧
新規のときは類似品を選択し、修正後形名登録をして下さい。
熱交換器のNo.を入力して下さい。
21
（1～20はユーザ登録熱交換器です。）
熱交換器 ＃ 3
999 次 頁
-9 前画面に戻る

ARTIFACT SHEET

Enter artifact number below. Artifact number is application number + artifact type code (see list below) + sequential letter (A, B, C …). The first artifact folder for an artifact type receives the letter A, the second B, etc.. Examples: 59123456PA, 59123456PB, 59123456ZA, 59123456ZB

____

Indicate quantity of a single type of artifact received but not scanned. Create individual artifact folder/box and artifact number for each Artifact Type.

☐ CD(s) containing:

- computer program listing ☐
  Doc Code: Computer — Artifact Type Code: P
- pages of specification and/or sequence listing and/or table ☐
  Doc Code: Artifact — Artifact Type Code: S
- content unspecified or combined ☐
  Doc Code: Artifact — Artifact Type Code: U

☐ Stapled Set(s) Color Documents or B/W Photographs
Doc Code: Artifact Artifact Type Code: C

☐ Microfilm(s)
Doc Code: Artifact Artifact Type Code: F

☐ Video tape(s)
Doc Code: Artifact Artifact Type Code: V

☐ Model(s)
Doc Code: Artifact Artifact Type Code: M

☐ Bound Document(s)
Doc Code: Artifact Artifact Type Code: B

☐ Confidential Information Disclosure Statement or Other Documents marked Proprietary, Trade Secrets, Subject to Protective Order, Material Submitted under MPEP 724.02, etc.
Doc Code: Artifact Artifact Type Code X

☐ Other, description: ______________________________
Doc Code: Artifact Artifact Type Code: Z

March 8, 2004